

This Page Is Inserted by IFW Operations  
and is not a part of the Official Record

## **BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning documents *will not* correct images,  
please do not report the images to the  
Image Problem Mailbox.**

## (12) UK Patent Application (19) GB (11) 2 250 790 (13) A

(43) Date of A publication 17.06.1992

(21) Application No 9026977.0

(22) Date of filing 12.12.1990

(71) Applicant

Rolls-Royce plc

(Incorporated in the United Kingdom)

65 Buckingham Gate, London, SW1E 6AT,  
United Kingdom

(72) Inventor

John Gilbert Ferguson

(74) Agent and/or Address for Service

V J Bird et al

Rolls-Royce plc, P O Box 31, Intellectual Property  
Department, Derby, DE2 8BJ, United Kingdom(51) INT CL<sup>5</sup>

F16J 15/32

(52) UK CL (Edition K)

F2B B13CX6

(56) Documents cited

GB 2191825 A GB 2021210 A

(58) Field of search

UK CL (Edition K) F2B

INT CL<sup>5</sup> F16J

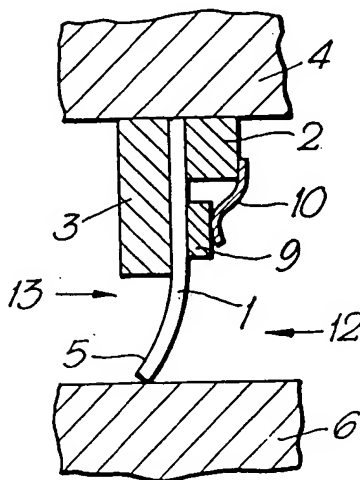
## (54) Brush seal

(57) A brush seal is formed by bristles tightly packed between two annular sideplates 2, 3 having different inner radii and secured to a housing. The free ends 5 of the bristles 1 are in rubbing contact with a shaft 6.

The differential pressure which the seal can support is increased by loading the bristles, by spring fingers 10 and loading ring 9, against the annular sideplate 3 having the smaller inner radius, the loading force being such that the bristles can still move in the plane of the seal.

As a result the amount of relative movement of shaft and housing that the seal can tolerate is not reduced.

Fig. 3B.



1/2

Fig.1A.

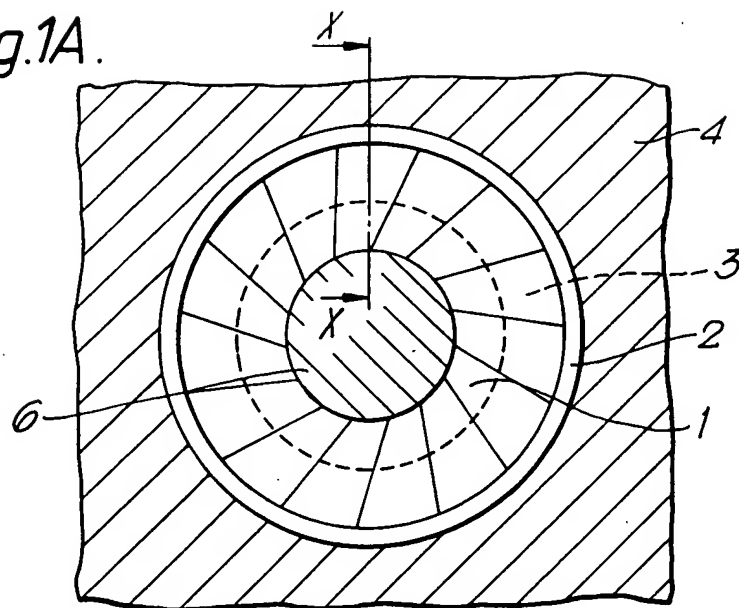


Fig.1B.

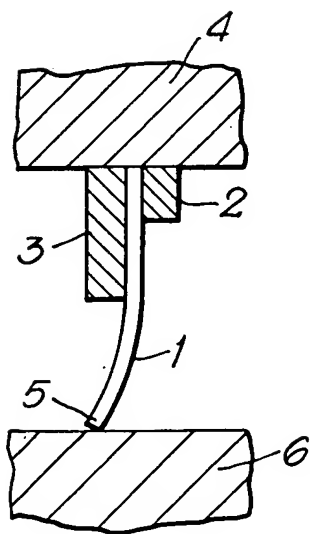
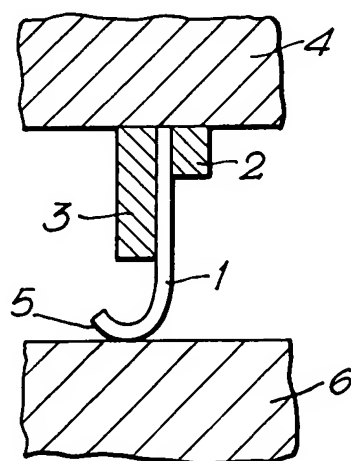


Fig.1C.



2/2

Fig. 2.

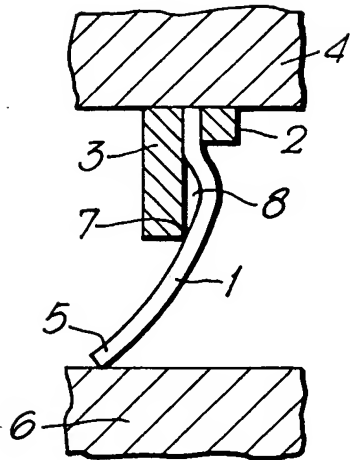


Fig. 3B.

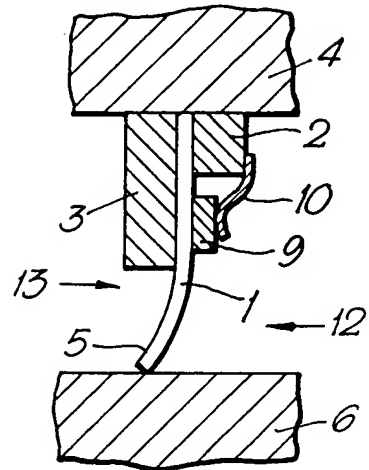
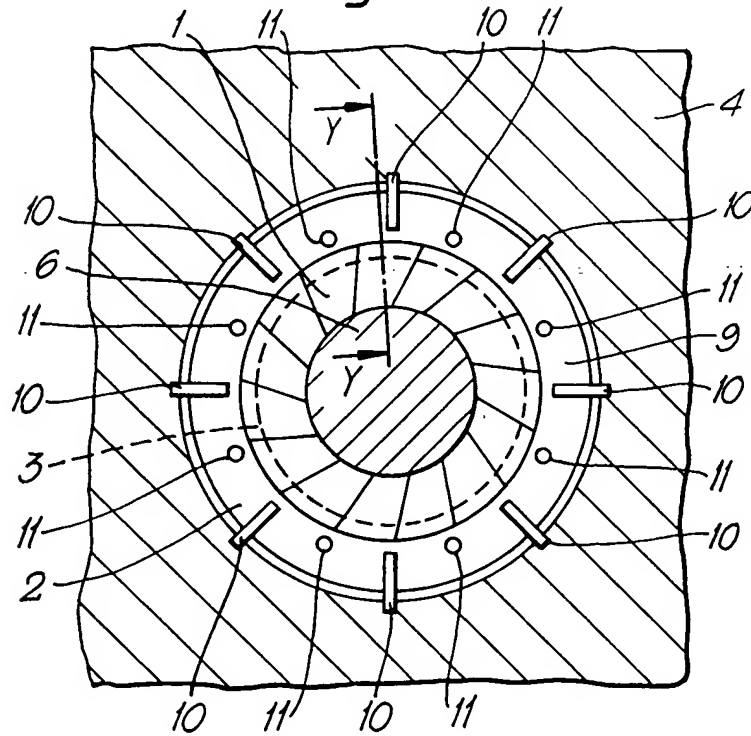


Fig. 3A.



**BRUSH SEAL**

This invention relates to brush seals.

Brush seals are a well known method of maintaining a fluid seal between two members which move relative to one another.

A known brush seal is shown in figures 1A and 1B, figure 1B is a cross section along the line X-X in figure 1A.

A large number of tightly packed bristles 1 are secured between a pair of annular sideplates 2,3 which are attached to a fixed housing 4. The free ends 5 of the bristles 1 are in rubbing contact with the surface of a shaft 6 which rotates relative to the housing 4.

As a result of the tight packing of the bristles and their rubbing contact with the shaft fluid leakage through the seal is low.

If the shaft 6 moves relative to the housing 4 the bristles 1 bend elastically in the plane of the seal to accommodate this movement returning to their original positions as the shaft moves back. Clearly the longer the bristles 1 are the greater the degree of movement of the shaft 6 so they will be able to accommodate without any of the bristles losing contact with the surface of the shaft 6 and reducing the quality of the seal.

If there is a pressure difference across the seal the pressure will exert a force on the bristles 1 which will cause them to bend along the axis of the shaft 6 towards the low pressure side as shown in figure 1B.

If the differential pressure across the seal is high enough the bristles 1 will bend so far that they lose contact with the surface of the shaft 6 and the seal will fail. The longer the bristles 1 are the larger the pressure forces on them and the degree of bending they suffer will be for a given differential pressure. As a result, the longer the bristles are the lower the pressure at which the seal will fail.

In order to overcome the problem that longer bristles for increased tolerance of movement will reduce the maximum differential pressure the seal can withstand annular sideplates 2,3 are arranged to have different inner radii.

The annular sideplate 2 on the high pressure side of the seal has a larger inner radius than the annular sideplate 3 on the low pressure side of the seal. As a result the bending of the bristles 1 due to the differential pressure across the seal is reduced because the bristles 1 are supported by the sideplate 3, and the ability of the bristles 1 to accommodate movement of the shaft 6 relative to the housing 4 is unchanged because the bristles 1 can bend in the plane of the seal from the edge of the sideplate 2.

Unfortunately there is still a problem with this arrangement. When a differential pressure is applied across the seal the bristles 1 bend towards the lower pressure side of the seal and as a result they protrude between the sideplate 3 and the shaft 6. As a result movement of the shaft 6 towards the housing 4 can result in some of the bristles 1 being pinched between the shaft 6 and the sideplate and bending perpendicular to the plane of the seal instead of in the plane of the seal, as shown in figure 1C. This can cause these

bristles 1 to bend so sharply that they snap or plastically deform, degrading the quality of the seal.

This invention was intended to produce a brush seal at least partially overcoming these problems.

This invention provides a brush seal comprising; first and second spaced apart members able to move relative to one another and defining between them a fluid flow channel; first and second sideplates attached to the first member, and extending towards the second member, the first sideplate extending further than the second sideplate towards the second member; a plurality of closely-packed bristles each having a first end secured between the two sideplates and a second end in contact with the second member so as to block fluid flow along said channel, and a loading element arranged to urge a number of the bristles against the first sideplate with a force such that the bristles can still slide between the first sideplate and the element.

The basis of this invention is the realisation that a bristle of a brush seal of the type shown in figure 1 bends as cantilever which is supported where the bristle is held between the two sideplates and where it bends over the end of the sideplate with the smaller inner diameter.

For example, looking at figure 2 a seal is formed between a housing 4 and a shaft 6 by a plurality of bristles 1 secured between a pair of sideplates 2,3 as before. In order to reduce the degree of pressure induced bending of the bristles 1 when a differential pressure is applied across the seal the sideplate 3 on the low pressure side of the seal has a smaller internal diameter than the sideplate 2 on the high pressure side.

It has been found that when a differential pressure is applied across the seal the bristles bend as a cantilever. That is the bristles 1 bend from the edge of the sideplate 2 with the larger inner radius towards the high pressure side of the seal, then curve back towards the low pressure side of the seal and are supported by the sideplate 3 having the lower inner radius at its inner edge 7 and then project towards the low pressure side of the seal between the sideplate 3 and the shaft 6. As a result the bristles 1 are not in contact with the sealplate 3 in the region 8 between the inner edge of the sealplate 2 and the inner edge 7 of the sealplate 3.

It has been realised that if a force is applied to the bristles 1 to urge them towards the sealplate 3 in the region 8 this will reduce the amount by which the bristles 1 protrude between the sideplate 3 and the shaft 6.

A seal embodying the invention will now be described by way of example only with reference to the accompanying diagrammatic figures in which;

Figure 3A shows a rotary brush seal employing the invention; and

Figure 3B shows a cross section along the line Y-Y in figure 3A, identical parts having the same reference numerals throughout.

A seal between a housing 4 and a shaft 6 is formed by a plurality of tightly packed bristles 1 and has a differential pressure across it. A first fluid 12 under a high pressure being on one side of the seal, and a second fluid 13 at a lower pressure being on the other



side of the seal. All of the bristles 1 are the same length. A pair of annular sideplates 2 and 3 are attached to the housing 4 and hold the bristles 1 between them. The free ends 5 of the bristles 1 are in rubbing contact with the shaft 6.

The annular sideplate 2 is on the side of the bristles 1 exposed to the high pressure fluid 12 and the annular sideplate 3 is on the side of the bristles 1 exposed to the low pressure fluid 13. The two annular sideplates 2 and 3 are coaxial and have different inner radii, the annular sideplate 2 on the high pressure side of the bristles 1 has a larger inner radius than the annular sideplate 3 on the low pressure side of the bristles 1.

On the high pressure side of the bristles 1 is an annular loading ring 9. The annular loading ring 9 is coaxial with the two sideplates 2 and 3. The outer radius of the loading ring 9 is slightly smaller than the inner radius of the sideplate 2 and the inner radius of the loading ring 9 is slightly larger than the inner radius of the sideplate 3.

The loading ring 9 is positioned on the high pressure side of the bristles 1 coplanar with the sideplate 2 and is urged against the bristles 1 by spring biasing by eight spring fingers 10 symmetrically spaced around the sideplate 2. Each of the spring fingers 10 has a first end 11 secured to the sideplate 2 and a second free end 12 in contact with the loading ring 9 which urges the loading ring 9 against the bristles 1.

As a result the loading ring 9 exerts an axial load on the bristles 1, urging them against the sideplate 3.

As explained above the load urging the bristles 1

towards the sideplate 3 reduces the distance that the bristles 1 project axially into the region containing the low pressure fluid 13.

The loading ring 9 has a larger inner radius than the sideplate 3 in order to allow the bristles to move more freely in the plane of the seal because the bristles 1 may splay out slightly and this would make it difficult for them to move between the sideplate 3 and the loading ring 9 if they had the same inner radius.

The spring fingers 10 are arranged so that the load exerted on the bristles 1 by the loading ring 9, pinching them between the loading ring 9 and the sideplate 3, is low enough that the bristles 1 are able to slide between the loading ring 9 and the sideplate 3 in the plane of the seal in order to accommodate movement of the shaft 6 relative to the housing 4.

The loading ring 9 has eight holes 11 which pass right through the loading ring 9 symmetrically spaced around it.

The holes 11 equalise the pressure on the two sides of the loading ring 9. If the holes 11 were not present the leakage of fluid under pressure between the bristles 1 might result in a differential pressure being generated across the loading ring 9, the side in contact with the bristles 1 being exposed to a lower pressure than the other. If this occurred the sealing ring 9 would exert an additional pressure generated force on the bristles 1. This could result in the bristles 1 being held between the sideplate 3 and the loading ring 9 with enough force to prevent movement of the bristles 1 in the plane of the seal, reducing the ability of the bristles 1 to accommodate relative movements of the

shaft 6 and the housing 4.

The loading ring 9 could be formed from a plurality of segments, each exerting a load on a proportion of the bristles 1.

Other methods of loading the loading ring 9 such as a conical spring or circular coil spring could be used, or the spring biasing means and loading ring 9 could be formed as a unitary structure. It would even be possible to have the sideplate 2, loading ring 9 and spring biasing means 11 all formed as a unitary structure.

The number of spring fingers 10 and holes 11 may be varied as is found convenient in practice.

The use of holes 11 is not essential, but is preferred.

The invention can, of course, be applied to a linear brush seal, employing a loading strip in place of a loading ring 9.

Either or both, sideplates 2,3 could be formed as surface features of the housing 4 rather than separate elements if preferred.

It is not essential that the loading ring 9 has a larger inner radius than the sideplate 3.

CLAIMS

- 1 A brush seal comprising; first and second spaced apart members able to move relative to one another and defining between them a fluid flow channel; first and second sideplates attached to the first member, and extending towards the second member, the first sideplate extending further than the second sideplate towards the second member; a plurality of closely-packed bristles each having a first end secured between the two sideplates and a second end in contact with the second member so as to block fluid flow along said channel, and a loading element arranged to urge a number of the bristles against the first sideplate with a force such that the bristles can still slide between the first sideplate and the element.
- 2 A brush seal as claimed in claim 1 and additionally including resilient means arranged to apply a force to the loading element, this force causing the loading element to urge the bristles against the first sideplate.
- 3 A brush seal as claimed in claim 2 in which the resilient means are spring fingers having a first end secured to the second sideplate and a second end in contact with the loading element.
- 4 A brush seal as claimed in any preceding claim in which the loading element has a closed orifice passing through it.
- 5 A brush seal as claimed in any preceding claim where a single loading element is arranged to urge

all of the bristles against the first sideplate.

- 6 A brush seal as claimed in any of claims 1 to 4 where a plurality of loading elements are used, each arranged to urge a proportion of the bristles against the first sideplate.
- 7 A brush seal as claimed in any preceding claim in which the first member surrounds the second member and the first and second members are able to rotate relative to one another.
- 8 A brush seal substantially as shown in or substantially as described with reference to figures 3A and 3B of the accompanying drawings.

- 10 -

**Patents Act 1977**  
**Examiner's report to the Comptroller under**  
**Section 17 (The Search Report)**

Application number

9026977.0

**Relevant Technical fields**

(i) UK Cl (Edition K ) F2B

(ii) Int Cl (Edition 5 ) F16J

**Databases (see over)**

(i) UK Patent Office

(ii)

Search Examiner

R L WILLIAMS

Date of Search

30 JANUARY 1991

Documents considered relevant following a search in respect of claims 1-8

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
A	GB 2 191 825 A      ROLLS-ROYCE	1
A	GB 2 021 210 A      ROLLS-ROYCE	1

Category	Identity of document and relevant passages	Relevant to claim(s)

#### Categories of documents

**X:** Document indicating lack of novelty or of inventive step.

**Y:** Document indicating lack of inventive step if combined with one or more other documents of the same category.

**A:** Document indicating technological background and/or state of the art.

**P:** Document published on or after the declared priority date but before the filing date of the present application.

**E:** Patent document published on or after, but with priority date earlier than, the filing date of the present application.

**&:** Member of the same patent family, corresponding document.

**Databases:** The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).